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ENTOMOLOGICAL NEWS

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The Use of the Mouthparts of Orthoptera During Feeding [1, 2, 3]

By S. K. GANGWERE

Descriptions of the mouthparts of Orthoptera (*sens. lat.*) are available in a host of laboratory manuals and textbooks because a grasshopper or a cockroach is usually chosen as the type to illustrate the mandibulate mouthparts of insects. These accounts of mouthpart structure are generally unsatisfactory as a source of information. More detailed and accurate treatments, *e.g.*, Yuasa's excellent comparative study (1920), are found in numerous contributions to entomological journals. In view of such an extensive literature on mouthparts it is surprising when one finds that there is comparatively little information about the function of mouthparts, individually and together, during feeding. The work of Popham on the feeding of the earwig *Forficula* (1958) is an outstanding exception. Treatments of variations in mouthpart use from group to group of the Orthoptera are apparently completely absent from the literature. It is the author's hope, therefore, that the present paper, which stresses group variations in both mouthpart use and adaptation, will help fill this void in our knowledge and that it, together with an earlier paper on the use of the mouthparts in grooming (Gangwere, 1958), will contribute to an improved understanding of the behavior of Orthoptera.

[1] Part of a dissertation offered to the Graduate School, University of Michigan, in partial fulfilment of the requirements for the degree of doctor of philosophy.

[2] Contribution No. 24 from the Department of Biology, Wayne State University, Detroit 2, Michigan.

[3] A 16 mm. motion picture film entitled "The Use of the Mouthparts of Grasshoppers during Feeding" and based on this research has been made available commercially by the Visual-Auditory Services, Wayne State University.

Methods of Study

Conventional laboratory and field observations were of use in revealing only the more general aspects of the feeding process. Consequently, it was necessary to employ a number of special techniques. Orthoptera were caged individually in small, rectangular glass chambers within which their feeding and other animals were denied food for twelve hours prior to a test. activities were observed under a dissecting microscope. Occasionally some species would not feed under such closely confined conditions. Some of them, *e.g.,* certain katydids, were placed free on food which rested on the stage of a dissecting microscope, through which they were observed; others, *e.g.,* cockroaches, were mounted (Frings' Method, 1946) and then observed by dissecting microscope several days later when they were calm. In some instances also, motion-picture photography was employed to analyze further the rapid feeding movements of the mouthparts of selected katydids and grasshoppers. The 16 mm. camera used for this purpose was a Ciné-Kodak Special II, fitted with a 63 mm. f2.7 lens and an 8 in. extension tube, and set at 64 frames per second. Illumination was provided by three Spencer microscope lamps fitted with heat filters to protect the insects. To assure immediate feeding all experimental animals were denied food for twelve hours prior to a test.

Observations

Two basic feeding mechanisms were found in the forty-one species of Michigan Orthoptera examined during the study. The first one, which occurs in grasshoppers and in walking-sticks, may be called *margin-feeding,* most feeding occurring along the margins of leaves or sometimes along a midrib, fold, or other leaf prominence. The second or *center-feeding* method occurs in katydids and in many other Orthoptera; the leaf-feeders among them usually attack a leaf at its center and then excavate it peripherally. There is an additional feeding pattern, *piercing,* in cone-headed katydids, in shield-backs, and sometimes in meadow grasshoppers. It is essentially a modification of center-feeding.

Margin-Feeding

A margin-feeding grasshopper usually mounts a leaf by straddling its edge. It first swings its head dorsad, carrying its hypognathous mouthparts far forward and upward, and then moves its head in a ventrocaudad swath while its mouthparts cut food from the edge of the leaf. By this means a small excavation is made in the leaf margin, this being deepened and elongated during successive swaths (fig. 1). When the excavation has been enlarged to a point where it cannot be deepened easily, the insect moves and attacks an adjacent portion of the leaf.

The grasshopper's labrum (fig. 2A) is essentially a dorsal lip covering the preoral cavity. Its primary function is to keep food within the preoral cavity, but its medial emargination also serves as a food guide within which the leaf margin always fits. The labrum is not rigid, however, for it is displaced both dorsad and toward its base by the mechanical pressure of the food. Its epipharynx, a structure on the ventral surface, appears to be sensory and may have a gustatory function.

The two mandibles (fig. 2B), which differ in form, bear both incisor and molar areas, the former being used for cutting loose pieces of food, the latter for masticating them. These areas may be employed alternately or simultaneously; thus, in band-winged, in slant-faced, and in some spine-breasted locusts of Michigan there is first a series of "bites" and then a series of "chews," the duration of each varying according to the species; in other spine-breasts of Michigan, in contrast, incision and mastication occur simultaneously each time the mandibles come together. The mandibular brustia are possibly tactile, but, judging from their comparative inflexibility, they may also help to align the food. This is apparently the case in the earwig *Forficula* (Popham, 1958).

Flattened, flap-like galeae (fig. 2C) are characteristic of grasshoppers. These structures, which partly cover the external faces of the mandibles, do not themselves move but rock back and forth as the mandibles displace them. They cover the

sides of the preoral cavity and help to maintain the medial alignment of the food, thus functioning as lateral lips.

The laciniae are heavily sclerotized and armed with teeth or maxadentes. They are absolutely indispensable in the feeding process, handling all of the food cut loose by the mandibles and perhaps even aiding in breaking loose fragments of very soft food. They move simultaneously and in opposite phase to the mandibles, coming together as the mandibles separate, separating as the mandibles come together. When the incisor dentes of the mandibles cut loose a piece of leaf, the laciniae push it into the preoral cavity between the molar dentes, which masticate it until it is swallowed. The laciniae also hold food to the mouth and may or may not be assisted in this function by the fore legs. The lacinarastra are probably tactile in function.

The maxillary and labial palpi of grasshoppers are densely covered with setae and with other sensilla and may be used for orientation as the animals move about as well as when they feed. When a grasshopper approaches food both pairs of palpi drum wildly, but once contact is made and feeding begins the drumming usually subsides to a slow tapping. Both sets of palpi may drum, tap, or occasionally brush the food as feeding continues, but usually only the labial palpi tap or drum, while the maxillary palpi are held with their apices near to or touching the food so that any movement of it away from alignment is perceived. During a mastication pause the drumming and tapping of the palpi retard and virtually stop. The palpi were not seen to push food into alignment, as they have been thought to do. They have been shown to possess organs of taste (Frings, 1946a) and of smell (Glaser, 1927).

The labium (fig. 2D) acts as a ventral lip, helping to hold food within the preoral cavity and, judging from its setal adornment, as a sensory apparatus. Although it, like the labrum, has a medial groove, it seldom serves to align the food, the soft, flexible paraglossae usually being displaced laterally and toward their base. The parapharynx (hypopharynx) born dorsomedially on the labium appears to be sensory.

Margin-feeding in walking-sticks apparently differs but little

from that in grasshoppers. *Diapheromera femorata,* the only species studied, straddles the leaf margins and takes slow, deliberate bites, which are remarkably square in outline. The insect's well-developed labral emargination always acts as a guide for the leaf margin. Its mandibles have fused incisor and molar areas; thus, it is not surprising that there is no distinct pause for mastication. *Diapheromera* usually leaves the principal veins intact, but when cutting through smaller ones it decreases its rate of chewing, bites harder several times until a given vein is severed, and then resumes feeding at the normal rate. Its galeae function as lateral lips and, to some degree, rock back and forth with the movements of the mandibles. Its laciniae are not powerful and do not need to be, for its mandibles cut well. The insect's labial and maxillary palpi tap lightly during feeding, the former less actively than the latter. Its labium is very deeply cleft, serving to align the leaf margin.

The foregoing generalized account of margin-feeding is based on numerous observations in the following Michigan species:

Acrididae: Acridinae
(Slant-faced Locusts)

Chloealtis conspersa
Chorthippus longicornis
Orphulella speciosa
Pseudopomala brachyptera
Syrbula admirabilis

Acrididae: Oedipodinae
(Band-winged Locusts)

Arphia p. pseudonietana
Arphia sulphurea
Camnula pellucida
Chortophaga viridifasciata
Dissosteira carolina
Encoptolophus s. sordidus
Spharagemon b. bolli
Spharagemon collare

Acrididae: Cyrtacanthacridinae
(Spine-breasted Locusts)

Melanoplus bivittatus
Melanoplus confusus
Melanoplus f.-r. femur-rubrum
Melanoplus keeleri luridus
Melanoplus b. bilituratus
Melanoplus s. scudderi
Paroxya hoosieri
Schistocerca alutacea

Phasmatidae (Walking-sticks)

Diapheromera femorata

Center-Feeding

The following account of center-feeding is based on bush and round-headed katydids but applies, with modification, to several

other groups. A leaf-feeding katydid begins feeding by positioning itself on the flat surface of a leaf blade. It first holds its mouthparts perpendicular to the leaf surface. When its mandibles come into contact with the leaf their incisor dentes begin to rasp it until a small hole is excavated. Once the mouthparts can be admitted into the hole the oblique phase of feeding begins; the mandibles, which are now at an angle to the leaf surface, cut irregular, scalloped pieces from the periphery of the hole (fig. 3). There is no invariable pattern for enlargement of the hole, for the animal sometimes moves forward and sometimes backward, but the swaths themselves are always ventrocaudad. Once the hole is large and framed by tough major veins, the katydid usually moves to an uneaten part of the leaf, where it begins feeding anew.

The insect's labrum (fig. 4A) acts as a dorsal lip and is sensory. It is not a food guide, and it lacks a medial emargination. Consequently, it is displaced dorsally, laterally, and toward its base by the incoming food.

The mandibles (fig. 4B) are provided with incisor and molar areas. Although one might expect a mastication pause, incision and mastication occur simultaneously, with one or two exceptions, each time the jaws come together.

Katydid galeae (fig. 4C) are lobular structures bearing numerous setae and provided apically with a sensory area. Like the flattened galeae of grasshoppers, they are lateral lips, but they are also an integral part of the feeding mechanism, for, along with the laciniae, they operate as a unit, pushing food into the preoral cavity, their action being in opposite phase to that of the mandibles. The galeae are specialized for brushing liquids and pulp of soft, succulent foods into the mouth, while

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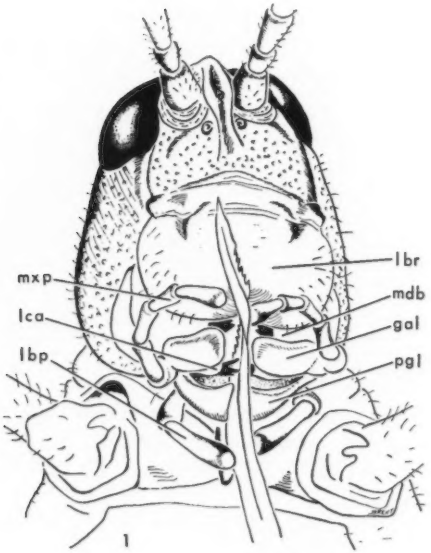
EXPLANATION OF FIGURES

FIG. 1. The head of the grasshopper *Romalea microptera*, showing the relationships of its mouthparts to a grass leaf on which it is feeding. Note that the leaf is aligned with the insect's labral emargination. This is an example of margin-feeding.

FIG. 2. The mouthparts of the slant-faced grasshopper *Syrbula admirabilis*, a margin-feeder. 2A—labrum, 2B—mandibles, 2C—left maxilla, 2D—labium.



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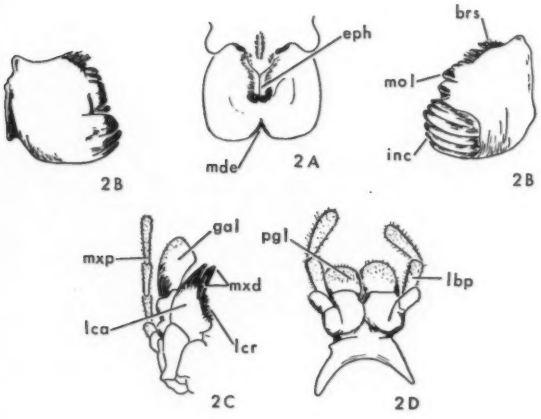


2B 2A 2B

2C 2D

the laciniae are used to push solid particles, a function for which their attenuate maxadentes adapt them.

The maxillae of katydids and of other center-feeders differ further from those of grasshoppers in that they are capable of considerable protrusion beyond the apices of the mandibles. This ability, which is made possible by adaptations of form and musculature of their cardos, is necessary if they are to scrape and to brush up particles loosened by the mandibles during the initial, perpendicular phase of feeding.

As a katydid moves about, its palpi, unlike those of grasshoppers, are sometimes not used but are flexed close to the head. This is not surprising when one considers that the average katydid probably sits higher from the ground than does the average grasshopper, and, hence, its palpi are less likely to come into contact with the ground. When food is near, however, the palpi first drum wildly and then retard their action, sometimes to a slow tapping, when actual contact with food is made. During feeding, the maxillary palpi usually do not retard as much as do the labial ones.

In both the initial, perpendicular phase of feeding and in the later oblique one the flexible labium (fig. 4D) is displaced by the incoming leaf. Obviously, then, it usually does not function as a food guide, but it is important as a ventral lip and as a sensory apparatus; its glossae, paraglossae, and palpi are densely setiferous.

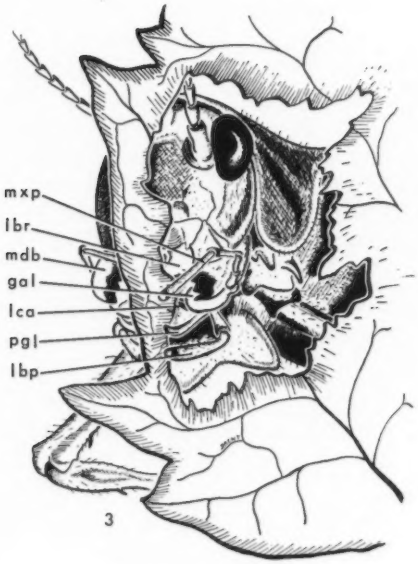
EXPLANATION OF FIGURES

FIG. 3. The head of the katydid *Amblycorypha oblongifolia*, showing the relationships of its mouthparts to an herb leaf on which it is feeding. Note that the leaf is held at an angle to the mouthparts and that it is not aligned with the labrum, which lacks an emargination. This illustrates the oblique phase of center-feeding.

FIG. 4. The mouthparts of the katydid *Amblycorypha rotundifolia*, a center-feeder. 4A—labrum, 4B—mandibles, 4C—left maxilla, 4D—labium.

All figures:

Brs—brustia
Crd—cardo
Eph—epipharynx
Gal—galea
Inc—incisor area or incisor dentes
Gls—glossa
Lbp—labial palpus
Lbr—labrum
Lca—lacinia
Lcr—lacinarastra
Mdb—mandible
Mde—medial emargination
Mol—molar area or molar dentes
Mxd—maxadentes
Mxp—maxillary palpus
Pgl—paraglossa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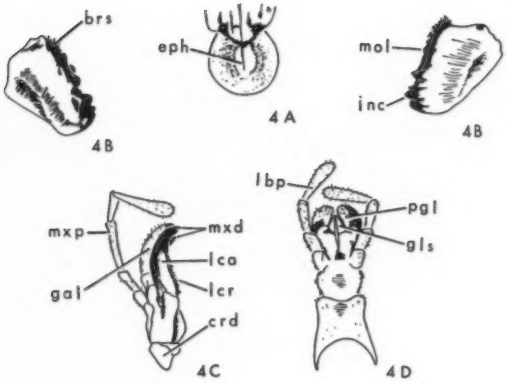
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4C
4D

The above description of center-feeding in bush and round-headed katydids also applies, with modification, to many other groups of Orthoptera and their relatives, including the camel crickets, cockroaches, crickets, earwigs, and usually the meadow grasshoppers. These groups, excepting the latter, are completely or in good part composed of scavengers with mandibles adapted for eating soft foods with rounded surfaces rather than flat leaves. They are alike in that they usually flex their palpi when not feeding, attack the general surface rather than the major prominences or margins of the food, use lobular galeae to brush in pulp and juices, and, lacking a labral emargination, do not align their food. The meadow grasshoppers vary their habits, being center-feeders when eating leaves and piercers when eating grass seeds.

The foregoing generalized account of center-feeding is based on numerous observations in the following Michigan species:

Dermaptera (Earwigs)
Doru a. aculeatum [1]

Blattidae (Cockroaches)
Blattella germanica
Parcoblatta pensylvanica

Tettigoniidae: Phaneropterinae (Bush and Round-headed Katydids)
Amblycorypha oblongifolia
Amblycorypha rotundifolia
Scudderia c. curvicauda
Scudderia f. furcata

Tettigoniidae: Conocephalinae (Meadow Grasshoppers)
Conocephalus f. fasciatus
Conocephalus nigropleurum
Orchelimum gladiator
Orchelimum volantum
Orchelimum vulgare

Gryllacrididae: Rhaphidophorinae (Camel Crickets)
Ceuthophilus meridionalis

Gryllidae: Gryllinae (Field Crickets)
Acheta pennsylvanicus

Gryllidae: Nemobiinae
Nemobius f. fasciatus

Gryllidae: Oecanthinae (Tree Crickets)
Neoxabea bipunctata
Oecanthus angustipennis

Piercing

Piercing, a modification of center-feeding, is well illustrated by *Neoconocephalus ensiger*. This cone-headed katydid holds a grass inflorescence to its mouth by means of its spinous legs. It punctures a given grain repeatedly with its mandibles, causing the exudation of fluid, which is brushed into the mouth by the insect's lobular galeae. After a time the grain has been punctured and manipulated sufficiently to break it loose from its rachilla and its enveloping scales. Then the grain is held in the preoral cavity by the mouthparts, including the labrum and labium, the latter two being displaced from their normal position while they function as lips. The labrum differs from the labium in this respect in that it is not merely pushed but is actually levated for admittance of the food. The right galea and lacinia, working synchronously, then oppose the action of the left galea and lacinia, thus imparting a rotation to the grain while it is repeatedly pierced by the incisor dentes of the mandibles. This forces out fluids and other materials, which are brushed into the mouth by the now synchronous activities of both laciniae and both galeae, the former handling particles, the latter fluids and pulp. Eventually most of the contents of the grain are removed and its collapsed remains swallowed.

The shield-backed katydids are also piercers, as is indicated by the feeding of one of them, *Atlanticus testaceus,* on meat. This insect repeatedly uses its mandibles to pierce a clump of meat, *e.g.,* hamburg steak, while the food is rotated by the galeae and laciniae. When a small portion has been pierced and manipulated sufficiently to break it loose from the main clump, it is individually manipulated, rotated, and pierced until reduced to a size small enough to be swallowed.

The foregoing generalized account of piercing is based on numerous observations in the following Michigan species:

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[1]The earwigs, although belonging to the Dermaptera, an order separate from the Orthoptera, are conventionally studied by orthopterists, thus justifying the inclusion of *Doru* in this account.

Tettigoniidae: Copiphorinae
(Cone-headed Katydids)
Neoconocephalus ensiger

Tettigoniidae: Decticinae
(Shield-backed Katydids)
Atlanticus testaceus

Tettigoniidae: Conocephalinae
(Meadow Grasshoppers)
Conocephalus f. fasciatus
Conocephalus nigropleurum
Orchelimum gladiator
Orchelimum volantum
Orchelimum vulgare

Summary and Conclusions

Examination of forty-one species of Orthoptera (*sens. lat.*) revealed two basic feeding mechanisms. These may be termed, respectively, *margin-feeding* and *center-feeding*. The latter is also subject to a modification, *piercing*.

In margin-feeding, which occurs in grasshoppers and in walking-sticks, the insect attacks a leaf by a series of ventrocaudad swaths with its mouthparts, the leaf margin invariably aligning with the insect's labral emargination. The incisor dentes cut the food as the mandibles come together; the laciniae, operating simultaneously but in opposite phase to the mandibles, force this cut food into the preoral cavity; and then the molar dentes masticate it. The galeae do not handle food but function only as lateral lips. The leaf margin may or may not align with the insect's labial groove. There is usually a distinct pause for mastication following each period of incision.

In the center-feeding of katydids and of many orthoptera, the insect usually attacks a leaf at its center, where rasping cuts are made with the mandibles as they are held perpendicular to the leaf surface. The small opening thus formed is then enlarged by the mandibles, which now cut ventrocaudad swaths while being held at an angle to the leaf surface. The laciniae and galeae operate together but in opposite phase to the mandibles as they handle food parts loosened by the action of the mandibles, the former brushing particles, the latter pulp and fluids into the preoral cavity. Neither the labrum, which lacks an emargination, nor the labium serves to align food. There is seldom a distinct pause for mastication.

Cone-heads, shield-backs, and meadow grasshoppers exam-

ined in this study feed by piercing, a modification of center-feeding. The labrum and labium are displaced outward by the food mass. As the mandibles come together repeatedly their incisor dentes pierce the mass until it is broken loose from any attachments. Following this, the food, while being rotated, is pierced repeatedly by the incisor dentes of the mandibles. Rotation is produced by the opposing action of the right galea and lacinia and the left galea and lacinia, those on a side operating together. Fluids, pulp, and particles thus released are then swept into the preoral cavity and between the molar dentes by the now synchronous action of both galeae and both laciniae, the former handling pulp and fluids, the latter particles. This continues until the food is reduced to a size appropriate for swallowing.

Close examination of the data from this study and particularly those relative to the Conocephalinae, which both center-feed and pierce, suggests that the mouthparts of katydids, crickets, and various other non-margin-feeders may adapt these insects both for center-feeding and for piercing and that the nature of the food taken by the species determines which mechanism is used.

Clearly, there exists a close correlation between the insects' mouthpart structure, their food, and their feeding pattern.

Acknowledgments

Drs. Irving Cantrall and Henry Townes, of the University of Michigan Museum of Zoology, and Alfred Beeton, of the U. S. Fish and Wildlife Service, kindly read and criticized the manuscript of the foregoing paper. Dr. Theodore Hubbell, also of the Museum, served as major advisor during the preparation of the dissertation from which this paper has been taken and expanded. Dr. Edward Voss, of the University of Michigan Herbarium, was consulted regarding terminology here adopted for the floral structure of grasses. Mr. Burt Brent, of Detroit, drew figs. 1 and 3. To these persons the author is deeply indebted.

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A New African Ant of the Genus Strumigenys, Tribe Dacetini

By WILLIAM L. BROWN, JR., Museum of Comparative Zoology, Harvard University

My good friend Prof. Francis Bernard, of the Zoology Department of the University of Algiers, has indicated to me that he thinks I should now formally give a name to the *Strumigenys* species that I described, but left unnamed in favor of Prof. Bernard's eventual description from material in his own collection, in my revision of the African *Strumigenys,* cited in the synonymy below. I therefore name this species

Strumigenys bernardi new species

"*Strumigenys* new species, Bernard ms.," Brown, 1954, Bull. Mus. Comp. Zool., 112: 16, worker. Type locality, by present designation: 10 miles east of Stanleyville, Belgian Congo (leg. N. A. Weber, No. 2225). Holotype in Weber Collection, eventually to be deposited in American Museum of Natural History, New York.

The description of the worker is given in the original reference, and the distinguishing characters are outlined in the key to the African *Strumigenys* in the same paper, pp. 10–12.

A New Genus and Two New Species of Neotropical Flies (Diptera; Drosophilidae)

By MARSHALL R. WHEELER, Austin, Texas

While visiting a cave on Mona Island, west of Puerto Rico, in October 1955, William Cross and Merle Kuns noticed some small flies riding about on the backs of land crabs. The discovery was described as follows by Dr. Cross (presently the Head of the Methods Development Unit, Screwworm Eradication Program, U. S. Department of Agriculture, Sebring, Florida):

"On October 18, 1955, at about 6:00 P.M., a cave, Cueva los Lirios, was entered by Captain Kuns and myself and a count was made of the bats leaving this cave during the next hour. At a few minutes after 7:00 P.M., we were back near the cave entrance where there were several holes in the roof and a large bromeliad on the floor. A number of land crabs (possibly *Coenobita*) were moving about among the bromeliad and rocks on the cave floor. On approaching one of these crabs and shining a bright light on it, we noticed a number of flies, apparently *Drosophila,* moving about over its carapace. In collecting a few it was observed that they could be frightened off the crab but would quickly return."

Several visits were made to the cave and eleven adult specimens of the fly were collected. The land crab involved was never identified with certainty, but it may have been *Cardisoma guanhumi* which is widely distributed in this region.

In February 1956, Dr. William B. Heed was making collections of Drosophilidae in Puerto Rico for the Genetics Foundation of the University of Texas, and had an opportunity to study the specimens from Mona Island. He determined that they were *Drosophila,* and that the species was probably undescribed, whereupon Dr. Cross very kindly donated the specimens to the *Drosophila* collection at the University of Texas. The species is described below as *Drosophila carcinophila* n. sp.

What appears to have been the same species of fly was collected earlier by Mr. H. G. Hubbard in 1894 on Montserrat, a

small island of the British West Indies, a member of the Leeward Group located approximately 250 miles southeast of Puerto Rico. His collections are now represented by three items in the Diptera collection of the U. S. National Museum: (1) a single puparium, labelled "Drosophila from mouth of land crab; Mntserrat, April 15, W. I.; H. G. Hubbard, collector;" (2) an empty pin to which we presume an adult fly had once been attached but which has since been lost, the pin bearing the same labels as the preceding; and (3) a portion of the mouthparts of a crab to which about 20 puparia are attached, bearing labels as follows: "Maxilla of land crab; April 14th, 94; Montserrat B. W. I.; Dipt. messmates; Drosophila from land crab; H. G. Hubbard, collector; Mntserrat, Apr. 14, W. I."

These puparia are of the size one would expect for the *Drosophila* from Mona Island. Each puparial segment bears a prominent transverse row of small reddish knobs, and there are two such rows, with fewer knobs, on the operculum. The posterior spiracles are pale and divergent; the anterior spiracles are sessile and are situated before the apex, somewhat as in certain species of *Megaselia* (Phoridae).

Drosophila carcinophila new species

♂♀. A small, dull brownish fly with three strong pairs of dorsocentral bristles; mesonotal hairs and bristles standing rather upright, giving a distinctly bristly appearance.

Front dull, light tannish brown; face paler. Carina high and thin, not sulcate. Arista with 4 dorsal and 2 ventral branches in addition to the terminal fork. Vibrissa single, strong, followed only by short hairs. Cheeks rather broad, a little less than width of 3rd antennal segment, yellowish but more brownish tinged just below lowest point of eye, the latter with thick pile. Palpi tan. Proclinate orbital about $\frac{3}{4}$ length posterior reclinate; anterior reclinate thinner, about $\frac{1}{2}$ length proclinate and situated just behind it at about $\frac{1}{3}$ the distance between the proclinate and the posterior reclinate. Inner verticals in front of outers, the latter only slightly more laterad in position.

Mesonotum light brown with rusty tinge. Three pairs of dorsocentral bristles, the anterior one presutural, situated just before the inner edge of the transverse suture; some acrostichal hairs enlarged in dorsocentral rows. Acrostichals irregular, in 2 rows posteriorly, roughly 4-rowed along middle of mesonotum, becoming 6-rowed more anteriorly; prescutellars slightly enlarged. Basal scutellars convergent. Pleura colored as mesonotum, paler below. Anterior sternopleural $\frac{2}{3}$ length posterior. Halteres pale. Legs pale, slender, the tarsal claws reduced. Sutural and anterior notopleural bristles strong, posterior notopleural shorter.

Abdominal tergites with rather pale brownish bands, weakly interrupted medianly, at least on basal segments. First and second tibiae with apical bristles, preapicals on all three. Wings hyaline; costa reaching to apex of 4th vein; third costal section with the small black bristles on the basal half or a trifle more. Costal index about 2.0–2.2; 4th vein index 2.2–2.4; 5x index about 2.0.

Female body length about 2.5 mm., wing, 2.0 mm. Male body length about 2.0 mm., wing, 2.0 mm.

Holotype male and 2 *paratypes,* labelled "Cueva los Lirios, Mona Is. PR; M. L. Kuns; 1 Nov. 1955." Eight paratypes labelled "Cueva los Lirios, Mona Is. PR; WHC; 20 Nov. 55." Two paratypes are being placed in the U. S. National Museum collection; the remaining types are in the Drosophila Type and Reference Collection of the University of Texas.

Discussion

Although the evidence is rather meager, it seems most likely that the adult flies from Mona Island and the puparia from Montserrat represent the same species. The adults are closely associated with the land crabs, running about over the carapace, while the larvae apparently feed on the debris (or on the microorganisms in the debris) on the mouthparts of the crabs. It would be interesting to know if the adults also feed on this debris.

Other Diptera have been found associated with crabs, but apparently never in such an intimate fashion. *Asyndetus carcinophilus* (Dolichopodidae) has been observed at the entrances of crab holes on the dry beach above tide level in Hawaii (Dr. W. W. Wirth, personal communication), and species of *Rhicnoessa* (Tethinidae), *Hecamede* (Ephydridae), and *Lasiopleura* (Chloropidae), as well as several species of mosquitoes have been found in and around crab holes. As far as we know, however, none of these is truly commensal on the crabs.

Van Beneden (1885, *Animal Parasites and Messmates,* Appleton, New York) pointed out the desirability, and difficulty, of distinguishing between parasites, messmates (*commensaux* or commensals), and mutualists. Writing with an interesting humanistic approach, he stated: "The messmate is he who is received at the table of his neighbour to partake with him of the produce of his day's fishing. . . . The messmate does not live at the expense of his host; all that he desires is a home or his friend's superfluities. . . . The greater part of those animals which have established themselves on each other, and live together on a good understanding and without injury, are wrongly classed as parasites by the generality of naturalists. Now that the mutual relations of many of these are better understood, we know many animals which unite together to render each other mutual assistance; while there are others which live like paupers on the crumbs which fall from the rich man's table." One suspects that Van Beneden would have considered *Drosophila carcinophila* an excellent example of a commensal of the pauper class.

MAYAGUEZA, new genus

This new genus from Puerto Rico is based upon thirteen specimens from the collection of the U. S. National Museum, Washington, D. C. I wish to thank Dr. Willis Wirth who arranged for the loan of the material, Mrs. Linda Kuich who prepared the figures of the head, and Dr. Frances Clayton who made the wing photograph.

The genus belongs with that group of genera of the Drosophilidae, subfamily Steganinae, which possess a bare to pubescent arista, strong prescutellars, divergent basal scutellars, and three nearly equal orbital bristles. It appears to be most similar to *Pseudiastata, Cacoxenus* and *Acletoxenus.* Some of the more useful recognition features of these genera, as compared with *Mayagueza,* are as follows:

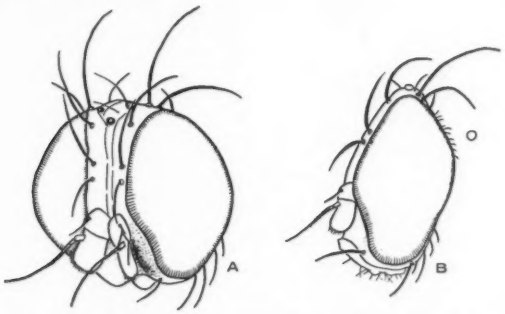


FIG. 1. Head of *Mayagueza argentifera.* A—semi-dorsal view; B—profile.

Mayagueza: Ocellars very small, directed upright, cruciate, not at all proclinate; postvertical bristles moderately small; front narrow; no sultural bristle; no propleural bristle; anterior dorsocentral quite small, situated very close to, and in line with, the posterior one; wing with distinctive clouds.

Pseudiastata: Ocellars small, proclinate; postverticals of normal size; front narrow or of moderate width; sutural bristle of normal size; propleurals absent; dorsocentrals not aligned, the long posterior ones moved more laterad; wings pictured or hyaline.

Cacoxenus: Ocellars of normal size, proclinate; postverticals rather small; front of moderate width; suturals moderately small; propleurals present; dorsocentrals aligned; wings hyaline.

Acletoxenus: Ocellars absent; postverticals small; front narrow; suturals small; presence of propleurals and alignment of dorsocentrals not reported; wings hyaline.

The argenteous mesonotum and pattern of wing maculation suggest certain species of *Leucophenga,* but there are no other important similarities.

The type species of *Mayagueza* is *M. argentifera,* the following new species.

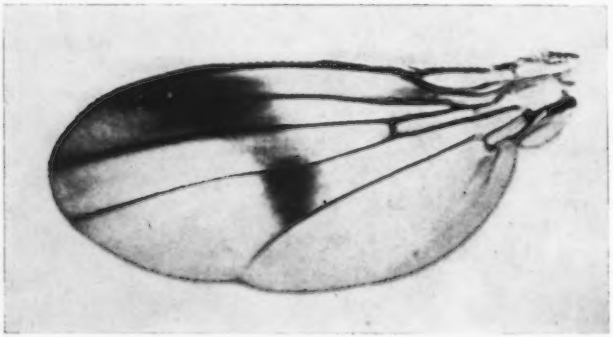


FIG. 2. *Mayagueza argentifera,* wing.

Mayagueza argentifera, new species

♂♀. A yellowish species with striking silvery to whitish bloom over the mesonotum. Front pale whitish yellow, very narrow in both sexes (Fig. 1); ocellar area contrastingly bluish gray. Face, antennae, cheeks, palpi and proboscis all yellow. Ocellar bristles small and thin, cruciate, directed upward rather than forward. Three stout orbital bristles, arranged as shown in the figure. Arista with short thick pubescence. Face not truly flat but rather evenly rounded over the central area. Cheeks very narrow. Clypeus narrow, pale; palpi small; vibrissa single and strong.

Disc of mesonotum light tan with prominent silvery to whitish bloom when viewed from certain angles. Pleura and legs wholly pale yellow. Basal scutellars divergent; apical scutellars about ⅔ length basals. Posterior dorsocentral long and strong, anterior one quite small, barely distinguishable from the adjacent

hairs. Acrostichal hairs in numerous irregular rows. One strong humeral; no sutural bristle; two strong sternopleurals, the anterior one only slightly shorter than the posterior. No propleurals.

Legs wholly pale; front femora without outstanding bristles. Strong apicals and preapicals present only on second tibia. Wings as in Fig. 2. Abdominal pattern not well preserved on any specimen, but the abdomen is apparently pale tannish yellow with some black median marks or splotches on the tergites. Genital arch of the male large, tapering below, the extreme lower apex bearing a single stout black tooth.

Body length, about 3.0 mm.; wing, 2.3 mm.

Holotype male and 12 *paratypes,* USNM collection, all bearing identical labels: Mayaguez, P. R., 15 June 1953; J. A. Ramos, collector.

New State Records of Zoraptera

By Garland T. Riegel and Max B. Ferguson
Eastern Illinois University, Charleston

Collections near the periphery of the known range of *Zorotypus hubbardi* Caudell have yielded the first records for the states of Iowa and Kansas. Also, three colonies were located in northeastern Oklahoma where previously this insect has been reported from only the very southeast corner of the state, apparently on the basis of one specimen (U. S. D. A. Econ. Insect Report 9(3) : 22, 1959).

The presence of *Zorotypus* in Iowa was first detected by the junior author in northern Wapello Co. (approximately 41°8′N). This is the most northerly record yet published, surpassing his DeWitt Co., Ill., record (below) and the Pennsylvania locality given by Gurney (Proc. Ent. Soc. Wash. 61(4) : 183–184, 1959). The Kirkville, Iowa, location is less than one degree

south of Evanston, Ill. (42°2′N), and this raises an interesting speculation about the dubious Evanston record published by Gurney in 1938 (Proc. Ent. Soc. Wash. 40(3): 61). Until collections are made further north in Illinois it must remain questionable, however.

The Nowata Co., Okla., site (95°37′W) seems to be the most westerly locality yet discovered, when compared with Houston, Texas, at 95°22′W, which was the farthest west *Zorotypus* had been found.

Other records given below are of interest in helping fill in the range of this species. The populations in old stumps discovered by Ferguson in Big Spring State Park, Mo., are the first we have found in a "natural" habitat (*i.e.*, other than sawdust piles), but are not as far north as the Knob Noster, Mo., collection recorded by Gurney in the first paper cited above.

The occurrence of *Zorotypus* is much less frequent as one goes north within the area where it is known to be. Whereas in the Missouri Ozarks almost every sawdust pile of sufficient age will have a population, such is not true in Illinois. Out of some fifty mills visited (some several times), only nine sawdust piles yielded Zoraptera. In Oklahoma they were in three out of six visited, in Kansas in two of five, in southern Iowa in three out of seventeen, while in southeastern Nebraska five mills were visited with negative results.

Except as otherwise noted, all the specimens listed below were taken in decaying sawdust piles. Most are preserved in the Spooner Insect Collection at Eastern Illinois University.

FLORIDA: Everglades National Park, Long Pine Key, Dade Co., XII–24–51, in rotten log, Richards & Stannard (Ill. Nat. Hist. Survey).

ILLINOIS: Near Bourbon, Douglas Co., VIII–9–58, N. E. Dearnbarger, 4 ♂, 4 ♀, 7 nymphs (some of the wingless females in this population showed slightly pigmented eyes); near Clinton, DeWitt Co., X–10–58, M. B. Ferguson, 7 ♂, 2 ♀; same, V–2–59, 7 ♂, 12 ♀, 5 N.; Cowden, Shelby Co., IX–5–58, Riegel & Ferguson, 12 ♂, 11 ♀, 23 N. (some wingless females with

pigmented eyes); near Dundas, Richland Co., VIII–4–58, Riegel, Basham, Dearnbarger, Herron, Jarrell, Michaels, Stanfield & Wiman, 44 ♂, 26 ♀, 2 ♀ N. with long wing pads, 17 N.; same, G. Riegel, 1 alate ♀; Grandview, Edgar Co., VIII–5–58, David Stanfield, 1 ♀, 17 N.; Jonesboro, Union Co., V–18–58, Groothius & Riegel, 1 ♂, 3 ♀; Lawrenceville, Lawrence Co., III–14–59, J. Hayes, 1 ♀; near Oblong, Crawford Co., VIII–4–58, Riegel *et al.*, 21 ♂, 18 ♀, 30 N.; near Yale, Jasper Co., VIII–4–58, Riegel *et al.*, 6 ♂, 4 ♀, 2 ♀ N. with long wing pads, 42 N.

INDIANA: Wadesville, Posey Co., VII–5–58, G. T. Riegel, 1 alate ♀, 5 ♂, 3 ♀, 4 N.

IOWA: Near Bloomfield, Davis Co., IV–24–59, Riegel, Ferguson, Hayes, Stanfield & Williams, 2 ♂, 2 ♀, 1 ♀ N. with long wing pads; near Farmington, Van Buren Co., V–24–59, Riegel *et al.*, 1 alate ♀, 8 ♂, 13 ♀, 2 N.; near Kirkville, Wapello Co., VIII–31–58, M. B. Ferguson, 1 ♂, 2 ♀, 1 N.

KANSAS: Chetopa, Labette Co., V–22–59, Riegel, Ferguson, Hayes, Stanfield & Williams, 1 ♂, 1 ♀ N. with long wing pads, 2 N.; Crestline, Cherokee Co., V–22–59, Riegel *et al.*, 9 ♂, 6 ♀, 1 ♀ N. with long wing pads.

KENTUCKY: Hickman, Fulton Co., V–11–57, Riegel, Groothius & Morgan, 2 ♂, 8 ♀, 3 ♀ N. with long wing pads, 5 N. (This population was in a buried log below ground level, in the remains of a very old, but small, sawdust pile.)

MISSOURI: Anniston, Mississippi Co., V–18–58, G. T. Riegel, 1 ♀, 1 N.; near Arroll, Texas Co., V–17–58, Riegel, Ferguson, Balding, Hayes, Hoffman & Morgan, 2 ♀, 9 N.; Big Spring State Park, Carter Co., V–17–58, under bark of pine and oak stumps cut off almost flush with the ground (wood determined by Dr. E. L. Stover), Ferguson & Riegel, 2 ♂, 2 ♀, 1 N. (many more specimens were seen than could be captured, and the best population seemed to be in the pine stump); Camdenton, Camden Co., V–12–56, Riegel *et al.*, 3 alate ♀ (one teneral), 26 ♂, 18 ♀, 2 ♀ N. with long wing pads, 32 N.; Carthage, Jasper Co., V–21–59, Riegel, Ferguson, Hayes, Stanfield & Williams, 1 ♂,

1 ♂ N., 1 ♀ N. with long wing pads; near Des Arc, Iron Co., V–16–58, Riegel & Ferguson, 18 ♂, 16 ♀, 16 N.; near Grassy, Bollinger Co., V–18–58, Riegel, Groothius, Hayes, Hein & Wall, 1 dealate ♀, 6 ♂, 8 ♀, 10 N.; Jackson, Cape Girardeau Co., V–18–58, Riegel *et al.*, 1 alate ♀, 3 dealate ♀, 26 ♂, 64 ♀, 7 ♀ N. with long wing pads, 16 N.; near Jewett, Madison Co., V–16–58, Riegel & Ferguson, 2 ♂, 5 ♀; near Mountain View, Howell Co., V–17–58, Riegel *et al.*, 9 ♂, 4 ♀, 1 ♀ N. with long wing pads, 2 N.; near New Hamburg, Scott Co., V–18–58, G. T. Riegel, 1 dealate ♀, 1 ♂; near Palmyra, Marion Co., VIII–16–58, G. T., G. G. & R. W. Riegel, Sr., 1 ♂, 6 ♀, 3 N.; Piedmont, Wayne Co., V–16–58, Riegel, Ferguson, Groothius, Morgan & White, 28 ♂, 58 ♀, 1 ♀ N. with long wing pads, 45 N., 3 eggs; near Spalding, Ralls Co., VIII–5–57, G. T. & R. W. Riegel, Sr., 11 ♂, 12 ♀, 4 ♀ N. with long wing pads, 47 N., 1 E.; Winona, Shannon Co., V–17–58, Riegel *et al.*, 10 ♂, 13 ♀, 1 ♀ N. with long wing pads, 6 N., 1 E.

OKLAHOMA: Near Hollow, Craig Co., V–22–59, Riegel, Ferguson, Hayes, Stanfield & Williams, 13 alate ♀, 168 ♂, 91 ♀, 4 ♀ N. with long wing pads, 76 N., 1 E. (this was the heaviest population that we have ever seen. Due to the press of time we did not collect as many specimens as we could have); Miami, Ottawa Co., V–22–59, Riegel *et al.*, 12 ♂, 6 ♀, 8 N.; near Nowata, Nowata Co., V–22–59, Riegel *et al.*, 25 ♂, 11 ♀, 9 N. (half of the apterous females in this population had slightly pigmented eyes).

TENNESSEE: Near Ridgely, Lake Co., V–10–57, Riegel *et al.*, 3 ♂, 1 ♀, 1 N.; near Troy, Obion Co., V–10–57, Riegel *et al.*, 2 dealate ♀, 18 ♂, 23 ♀, 1 ♀ N. with long wing pads, 5 N.

The Genus Dermacentor (Ixodides) in Nebraska

By William F. Rapp, Jr.[1]

In 1955, the author [2] published a short paper on the status of *Dermacentor variabilis* in Nebraska at that time. Since then, additional fieldwork has added materially to our knowledge of the genus *Dermacentor* in the State.

Dermacentor variabilis is the most wide spread "hard-bodied" tick in Nebraska. Figure 1 shows the known distribution of *D. variabilis* as of September 1, 1959. Our fieldwork indicates that this species is limited principally to deciduous flood plains throughout the State. Additional fieldwork, we believe, will further increase our knowledge of its distribution in the State.

Our studies indicate that mice of the genus *Peromsyscus* are the principal first host of *D. variabilis* in Nebraska. The second host appears to be one of the large mammals as adults have been taken on spotted skunk (*Spilogale putorius*), striped skunk (*Mephitis mephitis*), coyote (*Canis latrans*), dog (*Canis canis*), fox squirrel (*Sciurus niger*), eastern cottontail rabbit (*Sylvilagus floridanus*) and black-tailed jack rabbit (*Lepus californicus*). We do not have sufficient data as yet to indicate the preferred host of the adult tick. All specimens listed are in the collection of the Nebraska State Health Department.

The following is a list of new records obtained since the publication of our earlier paper. Blaine Co.: Dunning, 11 June 1959. Boyd Co.: Butte, 9 vi 1959. Burt Co.: Tekamah, 9 May 1956. Butler Co.: Bellwood, 15 June 1955. Cherry Co.: Nenzel, 11 June 1957. Custer Co.: Pressey Rec. Grounds, 11 June 1959. Hall Co.: Grand Island, 28 April 1959. Hamilton Co.: Hordville, 31 May 1958. Harland Co.: Republican City, 3 May 1956 (ex *Peromyscus* sp.). Howard Co.: Cushing, 29 April 1959 (ex *Sciurus niger*). Kearney Co.: 4 mi. south of Kearney, 11 June 1959. Keith Co.: Ogallala, 19 May 1958. Keya Paha Co.: Burton, 16 June 1959. Merrick Co.: Prairie Island, 31 May 1957; Chapman, 28 April 1959. Morrill Co.:

[1] Entomologist, Division of Sanitation, State Department of Health, Lincoln 9, Nebraska.

[2] Rapp, W. F., Jr., 1955, The Status of *Dermacentor variabilis* in Nebraska. *Entomological News*, vol. 66: 153–154.

Bridgeport, 22 May 1955; Bayard, 26 June 1956. Nance Co.: Fullerton, 30 April 1959. Perkins Co.: Grant, 8 April 1959. Saline Co.: Crete, 27 April 1955.

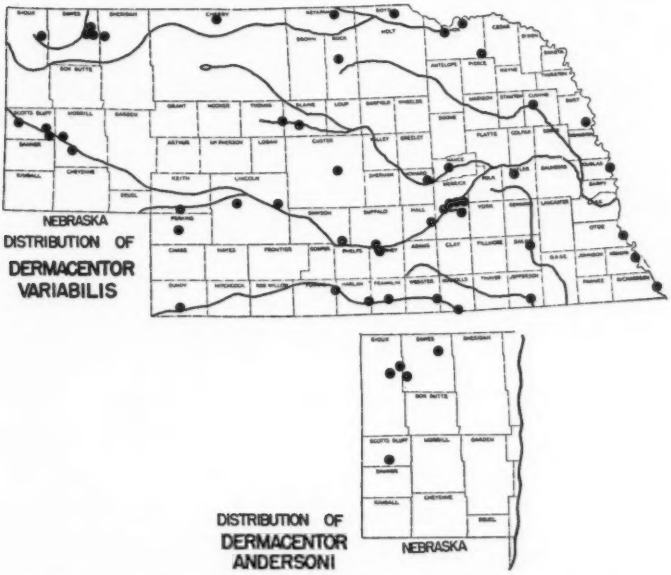
Dermacentor andersoni in Nebraska is limited to the yellow pine (*Pinus ponderosa*) areas (fig. 2) of the State, of which there are three major ones. The largest of these, the Pine Ridge area in Dawes and Sioux Counties, is a large horseshoe-shaped ridge. Although similar in flora to the Black Hills it is of a different geological period. Pine Ridge may be termed an "ecological island," as this region is isolated by short grass prairie. The second yellow pine area is the Wildcat Hills lying south of the North Platte River in Scotts Bluff and Morrill Counties. At the present time there are several isolated areas of yellow pine in the Wildcat Hills, but there is reason to believe that at one time yellow pine was widely distributed in this area. The third area of yellow pine in the State is along the Niobrara River from western Cherry County to its mouth in Knox County, and this too is an area of discontinuous stands.

To date, the majority of records for *D. andersoni* are from the Pine Ridge region. Only one specimen has been taken in the Wildcat Hills and none along the Niobrara River. Without doubt the Nebraska "panhandle" represents the eastern limit for this species.

In the Pine Ridge area it is interesting to note that apparently *D. andersoni* is restricted to the higher slopes where yellow pine is the dominant plant form, while on the lower slopes, where oak and deciduous shrubs are dominant, *D. variabilis* is found. There appears to be no well defined ectone between the deciduous areas and the yellow pine areas yet the two species of ticks do not seem to stray from one formation to the other. Examination of a large series of adults taken on Pine Ridge shows no evidence of hybridization.

The following is a list of the specimens of *D. andersoni* in the collection of the Nebraska State Health Department. Dawes Co.: Bryan Canyon, 21 May 1955; Chadron State Park, 19 May 1955. Sioux Co.: Harrison, 17 mi. east, 21 May 1955; Crawford, 8 mi. northwest, 16, 17 May 1959. Scotts Bluff Co.: Carter Canyon, Roubadeau Twp., 23 May 1955.

In Nebraska *D. andersoni* is of minor importance from the public health viewpoint. In the middle 1930's several cases of Rocky Mountain spotted fever were reported from Fort Robinson, which is located partly in Dawes County and partly in Sioux County. It is believed that most of these cases were the result of tick bites obtained while working in the Fort Robinson Timber Reservation which is located on Pine Ridge in Sioux



County. No cases of Rocky Mountain spotted fever have been reported in the State in the past 15 years. The author,[3] in an earlier publication, has reviewed the relationship between *D. variabilis* and tularemia in Nebraska. In general, it may be stated that in at least certain areas of the State *D. variabilis* is the principal reservoir for *Pasteurella tularensis.*

[3] RAPP, W. F., JR., 1957, "Ticks and Tularemia in Nebraska," *Nebr. State Med. J.* 42: 402–403.

EXCHANGES

This column is intended only for wants and exchanges, not for advertisements of goods for sale or services rendered. Notices not exceeding three lines free to subscribers.

These notices are continued as long as our limited space will allow; the new ones are added at the end of the column, and, only when necessary those at the top (being longest in) are discontinued.

Butterflies. Wish to exchange specimens for Japanese species. Please write to Ichiro Nakamura (Boy, age 16), 26 Aza-Nichiyama Obayashi Takarazuka-shi, Hyogo-Ken, Japan.

Phasmidae of nearctic area desired alive. Purchase or trade, drawing on large stock of major orders, worldwide. Domminck J. Pirone, Dept. Entomology, Cornell University, Ithaca, N. Y.

Nitidulidae and Rhizophagidae wanted in exchange for European beetles of all families. O. Marek, Zămberk 797, Czechoslovakia.

Wanted and Needed. We are compiling a history of entomology, and particularly, at present, of the amateur insect clubs that flourished 50 to 75 years ago. Will you who have knowledge of such early clubs or societies advise me, giving facts on the time of existence, members, etc., which you may have. J. J. Davis, Dept. of Entomology, Purdue University, Lafayette, Indiana.

Cockroaches (Blattoidea) of Japan, Okinawa, Formosa (Taiwan), and the Philippines are being studied in cooperation with Dr. K. Princis. Loans of specimens from that area are desired. A. B. Gurney, U. S. National Museum, Washington 25, D. C.

Orthoptera. Gryllinae (except domestic sp.) and **Pyrgomorphinae** of the world wanted in any quantity for work in morphology, taxonomy, cytology, and experimental biology; dry, or in fluid, or living. Write D. K. Kevan and R. S. Bigelow, Dept. of Entomology, McGill University, Macdonald College, Quebec, Canada.

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